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view of the physical nature of the country, the sparsity of population, and the nature of the government, it is remarkable not that Turkey has so few, but that she has so many railroads.

CORRESPONDENCE.

SOME OF THE DIFFICULTIES OF PRECISION IN CIRCUMPOLAR INSTRUMENTAL OBSERVATIONS.*

TO THE AMERICAN GEOGRAPHICAL SOCIETY:—All navigators, even in well-known seas, know the liability to serious error in establishing their positions upon the best charts by what is known as "Dead Reckoning," particularly when for days they have been groping in fogs, driven by gales, tossed by heavy seas and suffering from effects of abnormal weather.

Upon approaching dangerous coasts the careful navigator makes large safety allowances for the uncertainties attending such calculations which depend so largely upon individual judgment as to the strength and direction of the invisible forces, which are constantly at work and so frequently drag the ship to its destruction. Drift or leeway, the force and direction of capricious currents, uncertain variations of compass, local deviations, errors in marking the speed of the ship, possible oversight of men, all combined, make dead reckoning only an approximation of the true position of the navigator in any part of the ocean.

These elements of error are enormously exaggerated in the Arctic seas, and, if Dr. Cook's and Commander Peary's declared positions should depend upon dead reckoning alone, they might have extreme difficulty in proving to the satisfaction of competent judges that either of them had reached their objective. Without the corroborative evidence of astronomical observations, their statements of success would be regarded as mainly guess work. Their "log books" could be written, and courses and distances plotted on charts in New York, without either of them doing more than disappearing from public view for the time covered by their records.

Throwing aside the dead reckoning, except so far as it adds to the interest of their narrations, and may be corroborative in some measure of their progress, it would seem that observations of the sun's altitude, both for latitude and longitude, must be the only means of fixing, even with approximate certainty, the position of the observer in circumpolar regions. The natural horizon, broken by ice hummocks, obscured by vapour, radiation and mirage, gives but an uncertain point of contact with the sun's lower limb, and an artificial horizon is therefore a necessary part of the equipment.

Artificial horizons are of two descriptions—one of mercury and one a mirror. The former, when the temperature is at or below the freezing point, must be warmed artificially, and the latter levelled by spirit levels, adjustment screws, and be placed upon a firm, solid base. Unless the spirit levels are warmed in the temperatures recorded, the spirits would freeze and levelling by them would become impracticable, however quickly applied. The mirror horizon on an unstable base would not give as satisfactory or truthful results, as the warmed mercury which finds its own level.

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*Captain John S. Barnes, who makes this communication to the Society, was formerly of the United States Navy, and as a navigator of sailing ships, he was, for many years, charged with the responsibility of fixing with accuracy the hourly position of a ship upon long voyages in varying climates.

The allowances for refraction, excessive at such low altitudes of the sun, increased by the extreme cold and obliquity of the sun's rays passing through the misty atmosphere, and depending upon barometrical and thermometrical conditions, form elements of serious error in observations, depending largely upon the individual judgment of the observer.

The chronometers, or chronometer watches, regulated to Greenwich or Washington time in a temperate climate, cannot be expected to go on from month to month and year to year with absolute precision, particularly in such temperatures, whether carried on the person, or transported on sleds and subjected to violent shocks. Longitudes obtained by them may easily be erroneous—where one degree of longitude is barely one nautical mile. It is extremely doubtful if any navigator, however skilful, can find with approximate precision his longitude at or near the Pole, unless by a series of observations extending over a number of days, using the most accurate instruments and a perfectly correct chronometer.

The best made sextant, handled by a half-frozen, fur-clad man, cannot be infallible. It is doubtful if two observers at the same time and place, with separate but similar sextants would record the same altitude. Like all delicately adjusted instruments, extreme carefulness is necessary to preserve its integrity.

The results of Azimuth observations, if carefully and systematically made with proper instruments, would constitute valuable contributions to scientific knowledge, as to variations of the compass in Polar regions. It is to be hoped that Dr. Cook with his surveying compass, and Commander Peary with his theodolite, made frequent use of them, but the same difficulties in accuracy would prevail. It would be remarkable if either of the explorers preserved and can exhibit the actual figures of their astronomical observations and calculations.

Astronomical facts can not be created, manipulated, incorrectly stated or misapplied. An incorrect altitude at a given place and moment of Greenwich time will be apparent.

The navigating instruments used by Arctic explorers are necessarily few in number, light in weight, small in dimensions and delicate in construction, all subject to damage and errors, arising from the severe climate, the rough handling in sledge transportation, and are necessarily more or less incorrect in their renderings. All of them should be subjected to careful inspection on their return to observatories.

The astonishing physical endurance of the Arctic explorers under such trying conditions, their isolation, the constantly impending danger to life, benumbed by cold, half starved, fatigued almost beyond human limits, the absence of intelligent sympathy with the object by ignorant companions, without assistance in their scientific work, unite in making the stories of their exploits, matters of intense interest. One can only wonder that any men situated as Dr. Cook or Commander Peary describe themselves, could calmly make observations and work out the problems confronting them, with satisfaction to themselves or others.

Whether either or both of them ever reached the Geographical Pole remains yet to be proven, but the public has always sympathy for the relations of brave endeavour to accomplish what has been considered the impossible.

JOHN S. BARNES.

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